DEMONSTRATION OF AMINE ENHANCED FUEL LEAN GAS REBURN

At PSE&G'S MERCER STATION

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This paper presents preliminary nitric oxide (NO_x) reduction results of the first full-scale application of Amine Enhanced Fuel Lean Gas Reburn (AEFLGR) at PSE&G's Mercer Station. PSE&G, the Gas Research Institute (GRI) and Nalco/Fuel Tech are jointly sponsoring this demonstration project. GRI is the owner of Fuel Lean Gas Reburn™ (FLGR) Technology and has been involved throughout the development of both FLGR and AEFLGR.

The co-injection of urea with natural gas in pilot scale tests has enhanced the NO_x reduction potential of the natural gas. Pilot scale tests achieved NO_x reductions greater than 75% using 7% natural gas heat input and a urea net stoichiometric ratio (NSR) of 1.0. The goal of the PSE&G demonstration program is a 60-70% NO_x reduction using less than 10% natural gas with a urea NSR of 1.5 or less while maintaining carbon monoxide (CO) emissions below 100 ppm (corrected to 7% O_2).

Public Service Electric & Gas Mercer Station has two (2) 326 MW wall-fired wet bottom units designed by Foster Wheeler. Each unit has a separate superheat and reheat furnace. The test furnace is the reheat furnace of Mercer Unit 2, which is designated Furnace 22 by PSE&G. Four (4) AEFLGR injectors were designed with a capacity of 40 million Btu per hour each and installed at the existing selective noncatalytic reduction (SNCR) injection location on the back wall of Furnace 22.

Mercer Station was chosen as the demonstration site because it has years of commercial operating experience with the NO_xOUT urea-based SNCR system. Beginning next year, the station will need deeper NO_x reductions than those obtained with the existing SNCR system. PSE&G's economic analysis showed that AEFLGR would provide very cost-effective NO_x reductions if the pilot scale results could be approached or duplicated. Pilot scale results indicated that amine enhancement of FLGR could double the NO_x reduction achieved at essentially the same $/ton NO_x removal cost at Mercer Station. Both the low capital costs (no overfire air addition) and the low operating costs (low gas/urea feed rates) made AEFLGR technology attractive to PSE&G.

The AEFLGR process represents a synergistic combination of the Fuel Lean Gas Reburn™ (FLGR) process for NO_X reduction developed with GRI support by Energy Systems Associates (ESA) of Pittsburgh, Pennsylvania and the urea-based selective non-catalytic NO_X reduction (SNCR) process commercialized by Nalco Fuel Tech (NFT) of Naperville, Illinois. The injection of amine enhanced natural gas in the proper temperature window results in chemical reactions that reduce NO to molecular nitrogen within this window. The process relies on using controlled velocity turbulent jets for dispersing the chemical additives in the furnace. The amount of natural gas is controlled so as to maintain an overall fuel lean stoichiometry in the upper furnace. Therefore, additional air injection above the gas injection zone for completing burnout is not needed. A patent application is pending for AEFLGR.

The chemical kinetic mechanisms of FLGR and SNCR have many of the same selective reactions. The injection of natural gas in hot, low oxygen furnace gas results in the formation of hydrocarbon radicals (CH_i), and the injection of urea (NH_2-CO-NH_2) results in the formation of amine radicals (NH_i). Both of these processes reduce NO to molecular nitrogen through a series of very similar selective reactions. The SNCR reactions are highly efficient in reducing NO in a narrow temperature window of 1700 ^oF to 1900 ^oF. At higher temperatures, the process performance drops off due to oxidation of the amine additive to NO. At lower temperatures the chemistry is too slow and results in high reagent leakage. Due to the high efficiency of the selective reactions between the NH_i radicals and NO, very small quantities of the reagents are needed. The key to acceptable SNCR process performance is good mixing and reagent dispersion in flue gas, and injection in the proper temperature zone.

Using natural gas as a carrier for the amine reagent widens the acceptable reaction temperature window, allows amine injection at higher temperatures without amine oxidation to NO, and improves the kinetic rates of the critical chemical reduction mechanisms. The natural gas creates a locally reducing environment for the amine chemistry that raises the acceptable temperature window and prevents the oxidation reactions. Completion of the reactions at higher temperatures also decreases the chances of ammonia “slip”, a byproduct of both SNCR and selective catalytic reduction (SCR) processes.

To date at Mercer Station, the best results the AEFLGR system has achieved are 60% NO_x reductions at 190 MW up to 73% NO_x reductions at 135 MW with 5-7% natural gas usage rates and urea NSRs ranging from 1.0 to 1.5. At higher loads, NO_x reductions have been limited to 30-45% because of the single AEFLGR injection location presently available. This limits the temperature window available for the AEFLGR process to a single location in the boiler. The best results were obtained using AEFLGR on the back wall of the furnace, while attempting to simulate AEFLGR on the front wall of the furnace by using SNCR injectors located just above the top row of burners and cofiring natural gas in the top row of burners.

These initial results identified the boiler loads where the optimal temperature window for the AEFLGR process exists at the back wall injection location. Additionally, the results were promising enough for PSE&G to install a second set of four (4) AEFLGR injectors on the front wall just above the top row of burners. Because the AEFLGR process is dependent on the furnace gas temperature at the injection location, site-specific optimization is required to determine the optimal natural gas and urea injection rates at each injection location for a specific boiler load. AEFLGR at both the front wall and back wall of Mercer Furnace 22 is being optimized to extend the deep NO_x reductions obtained from 135 MW to 190 MW across all operating loads. Plans are underway to automate and expand the AEFLGR process to the entire unit for the 1999 NO_x reduction “ozone season.”